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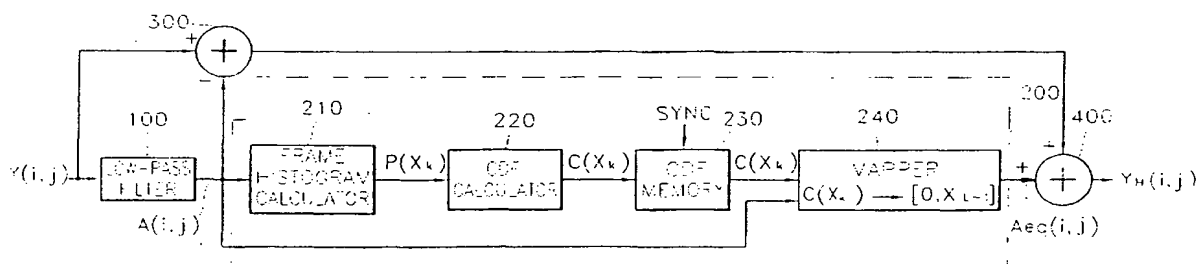
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(54) Image enhancing method using lowpass filtering and histogram equalization and a device therefor

(57) In an image enhancing method, an input image signal is lowpass filtered and then histogram equalized to become a contrast-enhanced signal. Then, the low-pass filtered signal is subtracted from the input image

signal. Afterwards, the subtracted value is added to the contrast enhanced signal, and the added result is output as an image enhanced output signal. Thus, the contrast of a given image signal is improved without an increase in background noise.

FIG. 2



respect to the given input signal  $A(i,j)$  is given by following equation.

$$A_{eq}(i,j) = c(A(i,j)) \cdot X_{L-1} \quad (8)$$

where,  $A(i,j) \in \{X_0, X_1, \dots, X_{L-1}\}$ .

Now, a preferred embodiment of the image enhancing device using lowpass filtering and histogram equalization according to the present invention will be explained with reference to Figures 1 and 2.

Referring to Figure 1, a lowpass filter 100 receives an input signal  $Y(i,j)$  and carries out lowpass filtering of such signal to output a lowpass filtered signal  $A(i,j)$ .

A histogram equalizer 200 equalizes the lowpass filtered signal  $A(i,j)$  output by the lowpass filter 100, thereby enhancing image contrast of the lowpass filtered signal.

A subtractor 300 subtracts the lowpass filtered signal  $A(i,j)$  output by the lowpass filter 100 from the input signal  $Y(i,j)$ . An adder 400 adds an improved signal  $A_{eq}(i,j)$  output by the histogram equalizer 200 to the output of the subtractor 300 and outputs a final output signal  $Y_H(i,j)$  which is expressed by the equation (1).

Figure 2 is a detailed block diagram of the device shown in Figure 1, in which a typical histogram equalization method is employed. In Figure 2, the same reference numerals were designated to the components similar to those shown in Figure 1, and the description will be focused on the histogram equalizer 200.

The histogram equalizer 200 includes a frame histogram calculator 210, a CDF calculator 220, a CDF memory 230 and a mapper 240.

The frame histogram calculator 210 receives the lowpass filtered signal  $A(i,j)$  (which can be denoted by  $X_k$ , also) output by the lowpass filter 100 in a picture unit, and calculates the probable density function  $P(X_k)$  which represents a gray level distribution in the lowpass filtered signal  $X_k$  according to the equation (6) by a unit of a picture. In the present embodiment, one frame is used for the picture unit. However, one field may be used for the picture unit, alternatively.

A CDF calculator 220 receives the probability density function  $p(X_k)$  output by the frame histogram calculator 210 and calculates a cumulative density function  $c(X_k)$  according to the equation (7).

A CDF memory 230 stores the cumulative density function  $c(X_k)$  calculated by the CDF calculator 220 by a unit of one frame, updates the stored value in response to a synchronization signal SYNC, and outputs a cumulative density function value  $c(X_k)$  corresponding to an input sample  $X_k$  stored one frame before. Here, a field sync signal is used for the synchronization signal SYNC when the picture unit is one field while a frame sync signal is used for the synchronization signal SYNC when the picture unit is one frame. The CDF memory 230 is also used as a buffer.

The mapper 240 reads out the cumulative density function value  $c(X_k)$ , which corresponds to the lowpass filtered signal  $X_k$  output by the lowpass filter 100 but is delayed by one frame, from the CDF memory 230 and maps the lowpass filtered signal  $X_k$  into a gray level of  $X_0$  to  $X_m$  according to the equation (8).

A frame memory can be further included in the histogram equalizer 200 for delaying the lowpass filtered signal  $X_k$  output by the lowpass filter 100 by one frame, so that a signal in the same frame as the cumulative density function value output by the CDF calculator 220 is input to the mapper 240.

The method of embodiments of the present invention can be applied in many fields associated with the improvement of image signal quality, such as broadcasting equipments, radar signal processing, medical engineering, and consumer electronics.

As described above, by lowpass filtering an input signal and histogram equalizing the lowpass filtered signal, image contrast may be improved while preventing an increase in noise.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

## Claims

1. An image enhancing method by histogram-equalizing an image signal represented by a predetermined number of gray levels, comprising the steps of:

(a) lowpass filtering an input image signal to output a lowpass filtered signal;

- (b) histogram equalizing the lowpass filtered signal to output a contrast-enhanced signal;
- (c) subtracting the lowpass filtered signal from the input image signal; and
- (d) outputting a signal produced by adding the subtracted value in said step (c) to the contrast enhanced signal.
2. An image enhancing method as claimed in claim 1, wherein said step (b) comprises the steps of:
- calculating a probability density function which represents a gray level distribution in the lowpass filtered signal by a picture unit;
- calculating a cumulative density function on the basis of the probability density function; and
- mapping the lowpass filtered signal into a gray level according to the cumulative density function.
3. An image enhancing method as claimed in claim 1 or 2, wherein the difference between the output signal and the contrast enhanced signal is the same as that between the input image signal and the lowpass filtered signal.
4. An image enhancing device by histogram equalizing an image signal represented by a predetermined number of gray levels, comprising:
- lowpass filtering means (100) for lowpass filtering an input image signal and outputting the lowpass filtered signal;
- histogram equalizing means (200) for histogram equalizing the lowpass filtered signal and outputting a contrast enhanced signal;
- detecting means (300) for detecting the difference between the input signal and the lowpass filtered signal; and
- outputting means (400) for adding the detected difference value to the contrast enhanced signal to output the added result as an output signal.
5. An image enhancing device as claimed in claim 4, wherein said histogram equalizing means (200) comprises:
- first calculating means (210) for receiving the lowpass filtered signal and calculating a probability density function which represents a gray

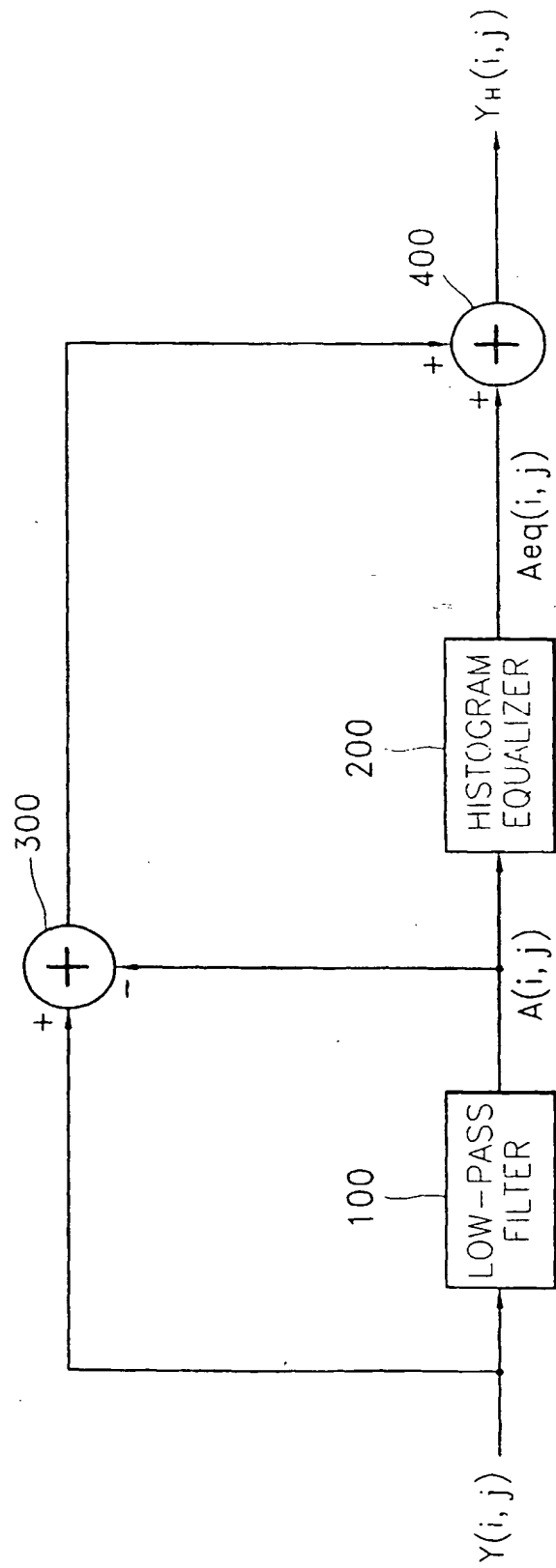
level distribution in the lowpass filtered signal by a picture unit;

second calculating means (220) for calculating a cumulative density function on the basis of the probability distribution function; and

mapping means (240) for mapping the lowpass filtered signal into a gray level according to the cumulative density function value.

6. An image enhancing device as claimed in claim 5, further comprising a picture memory (230) for delaying the lowpass filtered signal by one frame to output a signal in the same frame as the cumulative density function value output by said second calculating means.
7. An image enhancing device as claimed in claim 5, further comprising a buffer (230) for storing the cumulative density function values calculated by said second calculating means by a picture unit, updating the stored values in response to a synchronization signal, and outputting a cumulative density function value stored one frame before to said mapping means.

FIG. 1







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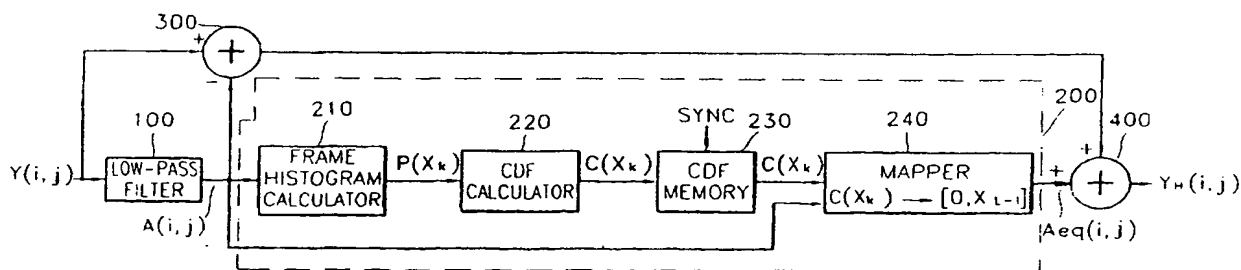
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FIG. 2





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# EUROPEAN SEARCH REPORT

Application Number  
EP 97 30 3287

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	US 5 317 427 A (ICHIKAWA KOUJI) 31 May 1994 * abstract * * column 5, line 44 - line 48 * * column 5, line 59 - line 65 * * column 6, line 58 - line 68; figure 1 * ---	1-7	G06T5/40
Y	ZHU YU-CHENG ET AL: "A HUMAN VISUAL MODEL BASED IMAGE HISTOGRAM MODIFICATION TECHNIQUE" PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON SYSTEMS, MAN, AND CYBERNETICS, BEIJING AND SHENYANG, AUG. 8 - 12, 1988, vol. VOL. 1, no. -, 8 August 1988, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 151-154, XP000091997 * abstract * * paragraph 2 * ---	1-7	
P, A	US 5 550 888 A (NEITZEL ULRICH ET AL) 27 August 1996 * column 5, line 62 - column 6, line 29; figure 1 * * column 10, line 30 - line 50 * ---	1-7	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G06T
A	LESZCZYNSKI K W ET AL: "DIGITAL CONTRAST ENHANCEMENT FOR ONLINE PORTAL IMAGING" MEDICAL AND BIOLOGICAL ENGINEERING AND COMPUTING, vol. 27, no. 5, September 1989, pages 507-512, XP000046396 * paragraph 2.1.2 * ---	1-7	
		-/--	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 10 June 1998	Examiner Gonzalez Ordonez. O
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date O : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US 4 825 297 A (FUCHSBERGER HERMANN ET AL) 25 April 1989 * abstract * * column 2, line 22 - line 36 * * column 5, line 15 - line 31; figure 7 * -----	1-7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>10 June 1998</b>	Examiner <b>Gonzalez Ordenez, O</b>
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons S : member of the same patent family, corresponding document			

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